Late Ordovician and Early Silurian Acritarchs

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Synopsis

The principal stratigraphical data for late Ordovician and early Silurian acritarchs are reviewed; at present they do not justify any formal zonation on a broad geographic scale. The systemic basal boundary stratotype at Dob's Linn, southern Scotland, has not yielded index acritarchs. A preliminary selection of taxa from correlative strata on Anticosti Island, Québec, eastern Canada, indicates that the area has the most continuous palynological record from at least the Ashgill to the late Llandovery, with the best potential for establishing detailed acritarch systematics and interregional correlation.

Introduction

In general, the biostratigraphical tool provided by the acritarchs is still only partly exploited for interregional correlation, for the following reasons: (i) sufficiently detailed systematic descriptions have become available only during the last fifteen years or so, through the use of SEM, and a coherent taxonomic framework is still lacking; (ii) precisely defined taxa are most often reported only from regions where their total stratigraphical range is not established; (iii) a large number of data relate to dispersed samples, for which there is no macrofossil age control. In particular, acritarchs of latest Ordovician and earliest Silurian age have received little documentation. This scarcity of data reflects the lack of palynological investigations rather than of suitable marine deposits, for these probably planktonic, organic-walled microfossils appear to be relatively weakly facies-controlled when compared with macrofossils. Nevertheless, the Ashgill extinction that affected numerous other fossil groups also involved the acritarchs. Differences in composition of assemblages between the end of the Ordovician and the beginning of the Silurian are indicated in the following areas: Anticosti Island, eastern Canada; southern Appalachians, U.S.A.; Belgium; and the Algerian Sahara. These differences are amplified by the absence of Hirnantian or Gamachian strata, except on Anticosti, where, on the basis of preliminary data (Duffield & Legault 1981, and author's personal observations), the disappearance of numerous Ordovician taxa seems to occur in the Gamachian. A marked change between acritarch associations from the late Ashgill and the Llandovery is mentioned briefly (Le Hérissé 1984) for the subsurface rocks in southern Gotland. Colbath (1986) has reviewed different hypothetical causes for these acritarch extinctions, ranging from the effects of sea-level and climatic changes associated with glaciation to a bolide impact model.

Review of data

The map (Fig. 1) shows the distribution of late Ordovician and early Silurian acritarchs and indicates detailed references. Numbers (see explanation of Fig. 1) refer generally to the most recent publication that indicates previous data; exceptions are Anticosti and Great Britain, for which further references are given. Anticosti and southern Scotland provided the two final candidate sections for the Ordovician–Silurian boundary stratotype considered by the Subcommission on Silurian Stratigraphy (Holland 1984). Since then the International Commission on Stratigraphy (Bassett 1985) has chosen to fix the base of the Llandovery Series, together with that of its lowest stage, the Rhuddanian, at Dob's Linn, southern Scotland; the boundary stratotypes for the two other Llandovery stages, Aeronian and Telychian, are located in the type area of the Llandovery in Wales (Cocks 1985).

Areas from which no index acritarchs are known (for example, the Ashgill of southwest France, Rauscher 1974) are omitted. Owing to the lack of agreement on precise correlation between the North American and British upper Ordovician standard successions (Barnes *et al.*

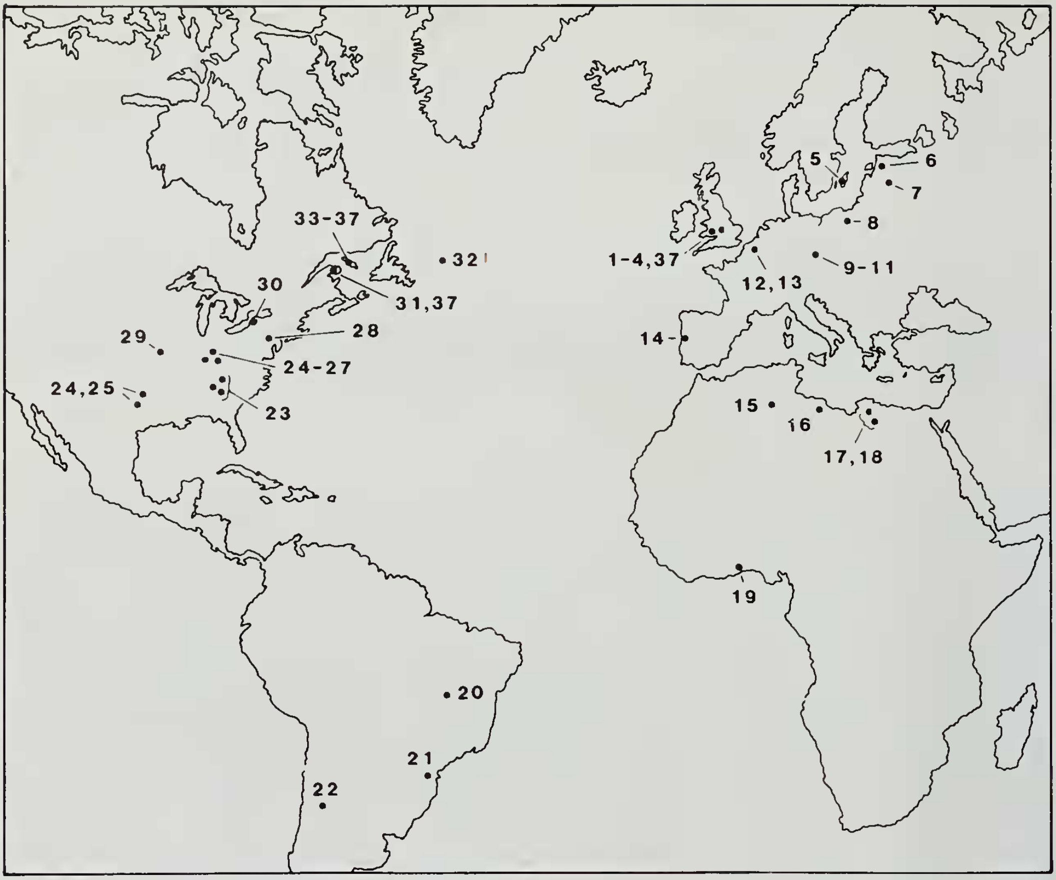


Fig. 1 Generalized world map showing late Ordovician and early Silurian acritarch localities. The following abbreviations indicate the information included in publications 1–37 listed below: (CA), undifferentiated late Caradoc and Ashgill; A, Ashgill; P, Pusgillian; R, Rawtheyan; H, Hirnantian; G, Gamachian; L, undifferentiated Llandovery, possibly including Rhuddanian; Rh, Rhuddanian; Ae, Aeronian; T, Telychian; p.d., palynological dating only. Chronostratigraphic units groups within parentheses are not differentiated from each other.

1, Hill 1974, Rh-T: 2, Aldridge *et al.* 1979, Rh-T: 3, Hill & Dorning *in* Cocks *et al.* 1984, Rh-T: 4, Downie 1984, Rh-T: 5, Eisenack 1968, A: 6, Eisenack 1963, A: 7, Umnova 1975, A, L: 8, Górka 1969, A: 9, Konzalová-Mazanková 1969, (PR): 10, Vavrdová 1974, A: 11, Vavrdová 1982, H: 12, Martin 1969, (CA), Rh-T: 13, Martin 1974, (CA), Rh: 14, Elaouad-Debbaj 1981, (CA), A, p.d.: 15, Jardiné *et al.* 1974, (C ?A), (AeT), p.d. in part: 16, Deunff & Massa 1975, ?C, p.d., ?Rh: 17, Molyneux & Paris 1985, A, p.d.: 18, Hill *et al.* 1985, (RhAe), p.d.: 19, Bär & Riegel 1980, (AL), p.d.: 20, Brito 1967, L, p.d.: 21, Gray *et al.* 1985, L, p.d.: 22, Melendi & Volkheimer 1985, L: 23, Colbath in press, (CA), (PR), (RhAe): 24, Loeblich & Tappan 1978, (CA), (PR): 25, Loeblich & McAdam 1971, (CA), (PR): 26, Loeblich 1970, (PR): 27, Colbath 1979, (CA): 28, Johnson 1985, L: 29, Wright & Meyers 1981, (CA), p.d.: 30, Miller & Eames 1982, Rh: 31, Martin 1980, (PR): 32, Legault 1982, (CA), p.d.: 33, Staplin *et al.* 1965, (PR): 34, Cramer 1970, (AeT): 35, Duffield & Legault 1981, 1982, G, Rh-T: 36, Jacobson & Achab 1985, (PR): 37, Martin in press and personal observation, G (at Anticosti only), Rh-T. [Since submission of this paper, Whelan (1986) has commented briefly on the acritarchs from Dob's Linn.]

1981; Ross *et al.* 1982; Shaver 1985), palynological references for both late Edenian and Maysvillian strata in U.S.A. are included. In the Llandovery Series, acritarch data given for the Rhuddanian sometimes include those for the Aeronian and Telychian. Localities where the sections begin only with the Aeronian or Telychian are omitted here and may be found in Martin (in press).

Europe

In Great Britain, no palynological work has been published on the Ashgill. The Ordovician–Silurian boundary stratotype strata at Dob's Linn (Cocks 1985) are composed of condensed, deep-water, graptolitic shales, the base of the Llandovery being coincident with the base of the *P. acuminatus* Zone. The whole succession, from the *Climacograptus peltifer* Zone (early Caradoc) upwards, contains rare, blackish acritarchs, but these are too poorly preserved to provide useful information. The type Hirnantian (Hirnant Limestone) at Cwm Hirnant quarry, near Bala, North Wales, yielded rare acritarchs belonging to either poorly-defined or remnant Arenig–Llanvirn taxa (personal observation). The Caradoc Series (Costonian to Onnian stages) in the type area of Shropshire contains well preserved assemblages (Turner 1984) of Caradoc age, associated with others derived from Tremadoc and Arenig–Llanvirn deposits. Rhuddanian microfloras from near Llandovery are both poorly preserved and of low diversity but permit (Hill & Dorning in Cocks *et al.* 1984) the recognition of three biozones characterized, on the basis of published lists, by the successive appearance of taxa that, for the most part, are long-ranging in the Silurian or are left in open nomenclature. The top of the Rhuddanian there also contains reworked, pre-Caradoc Ordovician material (Martin in press).

In the same region, and especially in the the Welsh Borderland (Hill 1974), partly published results for the Llandovery show, from the Aeronian onwards, a refined palynological zonation that may be compared with that outlined for Belgium (Martin 1969). Of particular significance are species of *Domasia* Downie, 1960 emend. Hill, 1974 and *Dilatisphaera williereae* (Martin) Lister, 1970.

In the Massif of Brabant, Belgium (Martin 1974), moderately well preserved acritarchs, mostly long ranging and including some known from the Tremadoc to the Arenig–Llanvirn, are from boreholes. Parts of these rock successions are assigned a late Caradoc and/or Ashgill age on lithological and structural grounds in the absence of diagnostic macrofossils; those of the basal Rhuddanian are dated by graptolites and include strata of the *P. acuminatus* Zone.

In the Baltic region (Gotland, Estonia, Latvia—Eisenack 1963, 1968; Umnova 1975), Poland (Górka 1969) and Czechoslovakia (Konzalová-Mazanková 1969; Vavrdová 1974, 1982), as in Portugal (Elaouad-Debbaj 1981), data are relatively few for the Ashgill and absent for the Rhuddanian. The only Hirnantian acritarchs so far illustrated come from the Prague region (Vavrdová 1982).

Africa and South America

Microfloras from boreholes in north Africa are well preserved. At the Grand Erg Occidental in the Algerian Sahara (Jardiné *et al.* 1974) acritarch zone F corresponds to the Caradoc and perhaps Ashgill; it also contains taxa characteristic of the Arenig–Llanvirn and is present too in deposits of the Illizi Basin attributed doubtfully to the *M. sedgwickii* Zone of the Aeronian. In Libya (Deunff & Massa 1975; Molyneux & Paris 1985; Hill *et al.* 1985) acritarchs from the late Ordovician and early Silurian, cited and partially figured, are dated with particular reference to palynological data from western Europe and central U.S.A. In Deunff & Massa (1975) the list of taxa alleged to have been found in the early Rhuddanian *C. vesiculosus* Zone indicates a post-Llandovery age and is not considered further here.

Acritarch data for the relevant interval in Ghana (Bär & Riegel 1980), Brazil (Brito 1967; Gray *et al.* 1985) and Argentina (Melendi & Volkheimer 1985) are dispersed and mainly without independent age control. The most noteworthy illustrated observation is that samples from Ghana said to occur at the Ordovician/Silurian boundary share only a single species, *Dactylofusa marahensis* Brito & Santos, 1965, with strata of the Maranhão Basin attributed to the Lower Silurian. In both cases the age is based on structural and palynological arguments.

North America

Publications referring to the eastern and central U.S.A. deal mainly with numerous new late Ordovician taxa from Oklahoma (Loeblich & McAdam 1971; Loeblich & Tappan 1978) and the Cincinnati area (Loeblich 1970; Loeblich & McAdam 1971; Loeblich & Tappan 1978; Colbath 1979); however, the acritarchs from the Richmondian Stage, which is correlated with part of the Ashgill Series, are from isolated samples. In the southern Appalachians (southwest

Virginia, northwest Georgia and east Tennessee), a consistent acritarch correlation, based largely on new taxa, is documented (Colbath, in press) for the passage from Ordovician to Silurian; but the presence of the Gamachian and earliest Rhuddanian in the region is debatable. An acritarch assemblage of undoubted Rhuddanian age in western New York State (Miller & Eames 1982) enables preliminary correlations to be made with assemblages in the southern Appalachians, Anglo-Welsh area and Belgium. A very few Llandovery, including perhaps Rhuddanian, acritarchs are known from central Pennsylvania (Johnson 1985).

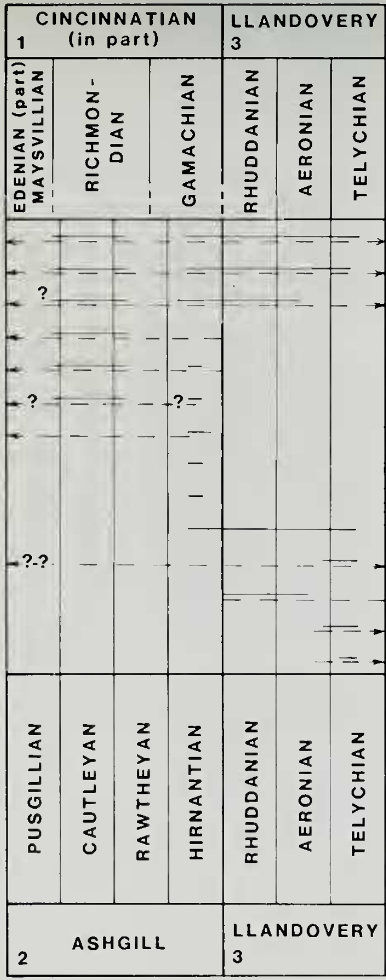
In eastern Canada, except for palynologically dated latest Caradoc or Ashgill strata in a borehole in the Labrador Sea (Legault 1982), data relate to the Province of Québec. Only reconnaissance studies are available for the pre-Hirnantian Ashgill of the Percé area (Martin 1980) in the Gaspé Peninsula. The White Head Formation at White Head (Lespérance 1985; Fig. 2 herein) has not yielded index acritarchs in the Hirnantian interval, and the basal Llandovery portion (base of Unit 6; personal observation) contains specimens deformed by crystal growth; some of the latter, for example *Eupoikilofusa* aff. *E. ampulliformis*, *sensu* Duffield & Legault 1981, are very characteristic of the Rhuddanian at Anticosti, from the base upwards of the Becscie Formation at Ellis Bay.

At Anticosti an Ordovician/Silurian boundary stratotype was proposed (Barnes & McCracken 1981) in an allegedly continuous limestone-shale succession in the upper part of the Ellis Bay Formation (*sensu* Petryk 1981) at Ellis Bay. The base of the Silurian is marked by the appearance of the conodont *Ozarkodina oldhamensis* (Rexroad, 1967); *Oulodus*? *nathani* McCracken & Barnes, 1981 is an auxiliary indicator for the boundary. However, Lespérance (1985) places the boundary higher and in the Becscie Formation, on the assumption that the appearance of the trilobite *Acernaspis* coincides with the base of the *P. acuminatus* Zone. The shallow marine platform deposits there are very rich in microfloras and in micro- and macrofaunas, except graptolites (see Lespérance 1981 for numerous contributions and earlier references). On the whole, the Ashgill and Llandovery acritarchs of Anticosti are very well preserved and relatively abundant, but have been described only partially (Staplin *et al.* 1965; Cramer 1970; Duffield & Legault 1981, 1982), apart from strata dated as *D. complanatus* Zone, assigned to the early or middle Ashgill (Jacobson & Achab 1985).

The Anticosti acritarchs

The quality of the palynological material at Anticosti and its age control based on shelly macrofaunas and conodonts justify a preliminary synthesis. The ranges of some taxa there are compared (Fig. 2) with those from other regions. The compilation is based on the references given in the general distribution of data (Fig. 1) and for the post-Aeronian of the same regions, following those assembled by Martin (in press; explanation of Fig. 1). This restricted choice of taxa is conditioned by personal examination of twelve samples (see Appendix) from the upper part of Member 4 of the Ellis Bay Formation, of Gamachian age, to the upper part of the Jupiter Formation, correlated with the Telychian (C_5) (Lespérance 1981). The choice could have been different, but in the present state of knowledge the comments would probably have been comparable with those below.

The observations of Duffield & Legault (1981) are confirmed with regard to the change in composition of acritarch assemblages just above the base of the Silurian as defined on the basis of the appearance of diagnostic conodonts (Barnes & McCracken 1981) within Member 7 of the Ellis Bay Formation. If the correlation proposed by Lespérance (1985) is accepted, the major change in terms of appearance of new acritarch taxa occurs within the late Gamachian, rather than in the early Llandovery. At its type locality, on the west side of Ellis Bay, the entire member, 1 to 4 m thick, is very poor in acritarchs. In particular, the locally developed biohermal bed, 1·5 to 2 m thick, above the systemic boundary is sterile. Immediately above this bed, from the base of the Becscie Formation (*sensu* Petryk 1981; sample A2B7) onwards, the majority of taxa known from other regions and of Ordovician affinities are absent. *Aremoricanium squarrosum* Loeblich & McAdam, 1971 (see synonymy in Jacobson & Achab, 1985: 171) is recognized in the early Richmondian, which is equated with latest Pusgillian to early Raw-



SELECTED ACRITARCHS FROM ANTICOSTI (QUEBEC, CANADA)	CANADA: GASPÉ	U.S.A.: CENTRAL	U.S.A.: NE & S APPALACHIANS	BALTIC REGION & POLAND	CZECHOSLOVAKIA	ENGLAND & WALES	BELGIUM	PORTUGAL	NORTH AFRICA
DIEXALLOPHASIS REMOTA	C-T		Rh-W	W	C-H	Rh-Lu	C-D		(AeT)-D
"HOGKLINTIA DIGITATA-H. VISBYENSIS"	(RhT)T	(AeT)W	W	pC-W		W	Rh		
GONIOSPHAERIDIUM OLIGOSPINOSUM	(RhT)			pC-W					
AREMORICANIUM SQUARROSUM	(PR)	(CA)A			H				Ap.d.
ORTHOSPHAERIDIUM RECTANGULARE		A	pC-A					(CA)	
ORTHOSPHAERIDIUM INSCULPTUM	(PR)	A						Ap.d.	C?p.d.
BALTISPHAERIDIUM PLICATISPINAE				pC-A					
PHEOCLOSTERIUM SP.NOV.									
GEN. & SP. NOV. cf. RHOPALIOPHORA SP.									
MULTIPLICISPHAERIDIUM SP. 1									
TYLOTOPALLA SP.	(RhT)		A-W			Rh-W	(CA)Rh		
EUPOIKILOFUSA aff. E. AMPULLIFORMIS	Rh(RhT)								
DOMASIA SP.	T	(AeT)W	(AeT)W	TW		Ae-W	Ae-W		(WLu)pd
DILATISPHAERA WILLIEREAE	T					T-?Lu	Ae-T		

1 North American standard
2 British standard
3 I.U.G.S. standard

——— Occurrence of taxon on Anticosti
— — — — Occurrence of taxon elsewhere

pC: Ordovician, pre-Caradoc, C: Caradoc, A: Ashgill, P: Pusgillian, R: Rawtheyan, H: Hirnantian, Rh: Rhuddanian, Ae: Aeronian, T: Telychian, W: Wenlock, Lu: Ludlow, D: Devonian, p.d.: palynological dating, chronostratigraphic units in parentheses are undifferentiated, ? before chrono stratigraphic symbol: dubious record of taxon, ? after chronostratigraphic symbol: dubious age attribution.

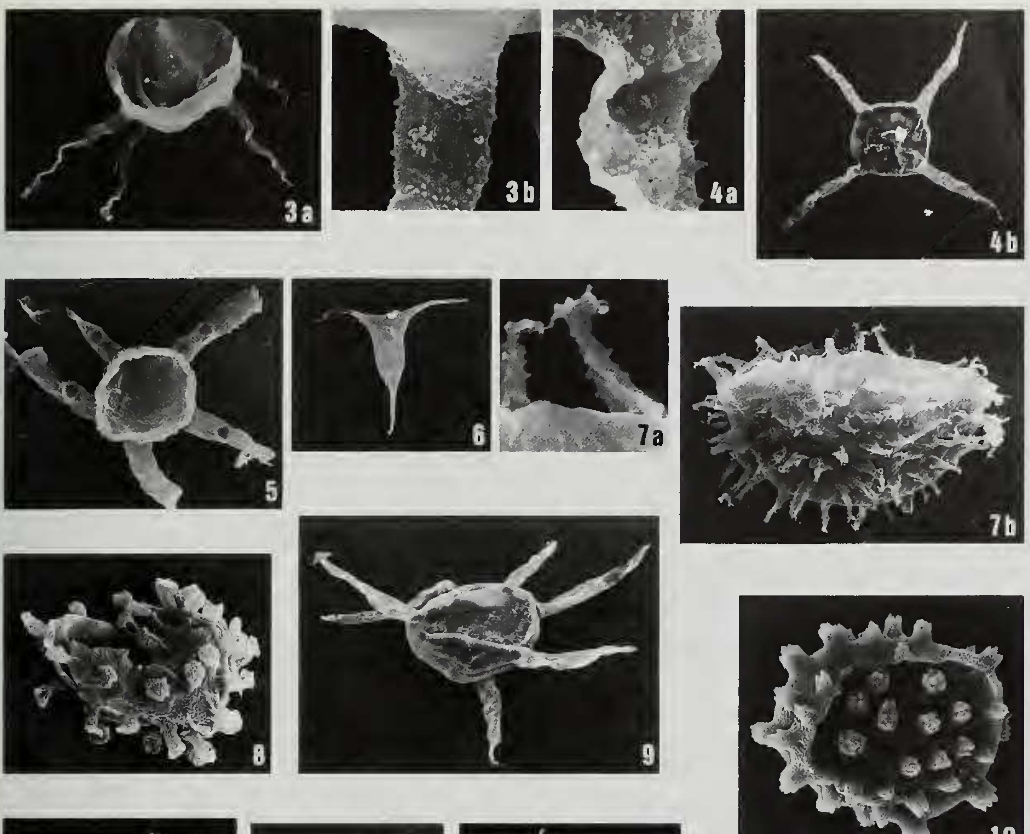
Fig. 2 Ranges of selected Anticosti acritarchs in other regions.

theyan by Barnes *et al.* (1981). The disappearance of *Orthosphaeridium rectangulare* (Eisenack) Eisenack, 1968 (Figs 4a, b; see synonymy in Elaouad-Debbaj 1981: 48) and of *O. insculptum* Loeblich, 1970 (Figs 3a, b) occurs within an unobserved interval in the Gamachian, between the upper parts of Member 5 (about 5 m below its top; sample A2B3) and Member 6 (0·3 m below its top; sample A2B4) of the Ellis Bay Formation. *Baltisphaeridium plicatispinae* Górka, 1969 (Fig. 9) extends, according to Duffield & Legault (1981), into Member 7, below the biohermal bed. The appearance of taxa of Silurian affinities, which occurs mainly and progressively from the base of the Becscie Formation onwards, begins in the Gamachian, no later than the upper part of Member 5 (sample A2B3), source of the present example of *Multiplicisphaeridium* sp. 1, *sensu* Duffield & Legault 1981 (Fig. 16). The latter recalls the '*M. forquiferum–M. forquillum*' group found by Cramer & Díez (1972) in the late Llandovery of Kentucky. *Eupoikilofusa* aff. *E. ampulliformis* (Figs 14a, b), which appears at the base of the Becscie Formation (sample A2B7), earliest Llandovery, is close to a Llandovery species known from the early Rhuddanian in Belgium (Martin 1974). The entry of *Domasia* Downie, 1960, emend. Hill 1974 (Fig. 6) and *Tylotopalla* Loeblich, 1970 (Fig. 10) on the one hand, and of *Dilatisphaera williereae* (Martin) Lister 1970 (Fig. 5) on the other, occurs in the Jupiter Formation at levels that are correlated (Barnes & McCracken 1981) respectively with the late Aeronian (C_1–C_2; sample A6A, about 3 m above base of Member 3) and with the Telychian (C_5; sample A7A1, 4 m below top of the Jupiter Formation). As yet no diacrodian has been identified from the upper part of the Gamachian, and no form suspected of being reworked from the Ordovician has been found in the Llandovery of Anticosti.

The richness and variety of the microfloras in the Gamachian and Llandovery at Anticosti will lead inevitably to the introduction of new taxa, some of which will be index fossils. As an example, two forms from the Ellis Bay Formation (sample A2B3) are illustrated for the first time here and left in open nomenclature: *Pheoclosterium* sp. nov. (Figs 7a, b) and Gen. et sp. nov. cf. *Rhopaliophora* (Fig. 8). The only species formally assigned to the former genus, *Pheoclosterium fuscinulaegerum* Tappan & Loeblich, 1971, is characteristic of the late Ordovician. Its range (see Jacobson & Achab 1985 for all references) is from the Edenian of Indiana (Kope Formation; Tappan & Loeblich 1971; Colbath 1979) and from the Onnian, highest Caradoc, in Shropshire, England (upper part of Onny Shales; Turner 1984) to the Hirnantian in Czechoslovakia (Kosov Formation, Vavrdová 1982). The second acritarch, cf. *Rhopaliophora*, differs from that exclusively Ordovician genus in its opening and resembles '*Hystrichosphaeridium*' *wimani*

Figs 3–16 Acritarchs from Anticosti. All figured specimens are in the type fossil collection of the Geological Survey of Canada, Ottawa, and have numbers with the prefix GSC.
Figs 3, 4, 7–9, 12, 15, 16: sample A2B3, Ellis Bay; Ellis Bay Formation, upper part of Member 5, Gamachian. Figs 11, 13, 14: sample A2B7, Ellis Bay; lowermost Becscie Formation, Llandovery, correlated with Rhuddanian, A_{2-4}. Figs 5, 6, 10: sample A7A1, 4 km southeast of Pointe Sud-Ouest; upper part of Jupiter Formation, Llandovery, correlated with Telychian, C_5. Age assignments according to Lespérance (1981).

Fig. 3 *Orthosphaeridium insculptum* Loeblich 1970. GSC 82877. Fig. 3a, × 400; Fig. 3b, enlargement, × 3000, of base of left process. **Fig. 4** *Orthosphaeridium rectangulare* (Eisenack) Eisenack 1968. GSC 82878. Fig. 4a, enlargement, × 2000, of base of left lower process. Fig. 4b, × 200. **Fig. 5** *Dilatisphaera williereae* (Martin) Lister 1970. GSC 82879, × 1000. **Fig. 6** *Domasia limaciformis* (Stockmans & Willière) Cramer 1970. GSC 82880, × 500. **Fig. 7** *Pheoclosterium* sp. nov. GSC 82881. Fig. 7a, enlargement, × 3000, of upper median processes. Fig. 7b, × 750. **Fig. 8** Gen. et sp. nov. cf. *Rhopaliophora* sp. GSC 82882, × 300. **Fig. 9** *Baltisphaeridium plicatispinae* Górka 1969. GSC 82883, × 300. **Fig. 10** *Tylotopalla* sp. GSC 82884, × 750. **Figs 11, 12** '*Hogklintia digitata–H. visbyensis*'. Fig. 11, GSC 82885, × 250. Fig. 12, GSC 82886, × 100. **Fig. 13** *Goniosphaeridium oligospinosum* (Eisenack) Eisenack 1969. GSC 82887, × 250. **Fig. 14** *Eupoikilofusa* aff. *E. ampulliformis, sensu* Duffield & Legault, 1981. GSC 82888. Fig. 14a, × 1000; Fig. 14b, enlargement, × 5000, of lower right part of vesicle. **Fig. 15** *Diexallophasis remota* (Deunff) Playford 1977. GSC 82889, × 500. **Fig. 16** *Multiplicisphaeridium* sp. I, *sensu* Duffield & Legault 1981. GSC 82890, × 500.


3a
3b
4a
4b
5
6
7a
7b
8
9
10
11
12
13
14a
15
16
14b

Eisenack, 1968, determined by its author from the latest Ashgill of Gotland (Bornholmer Stufe F2 from an erratic boulder at Oil Myr).

On Anticosti, in both the Ashgill and the Llandovery, there are geographically widespread forms with long stratigraphical ranges that are difficult to define because of their wide, continuous morphological variability within a single sample; examples are *Diexallophasis remota* (Deunff) Playford 1977 (Fig. 15) and the '*Hogklintia digitata–H. visbyensis*' complex (Figs 11, 12). The recurrent abundance in certain Ordovician and Silurian strata, notably on Anticosti and in the Baltic region, of the latter complex and of, for instance, *Goniosphaeridium oligospinosum* (Eisenack) Eisenack 1969 (Fig. 13) probably results from particular palaeoenvironmental conditions; the latter led Cramer & Díez (see 1974 for earlier references) to postulate a certain degree of provincialism linked to palaeolatitudes for Silurian acritarchs.

Acritarch data for the latest Ordovician and earliest Silurian are as yet too disparate to permit reliable palaeogeographic reconstructions. Data from Anticosti indicate affinities and possibilities for correlation as follows. The Gamachian microfloras contain taxa known from the late Ordovician of central U.S.A. and/or the pre-Hirnantian Ashgill of Gaspé, and from the Ordovician of Europe (Baltic region and Portugal) and North Africa (Libya). In particular, the evolutionary scheme proposed by Loeblich & Tappan (1971) for the genus *Orthosphaeridium* Eisenack 1968, notably in part of the Cincinnatian of central U.S.A. and in the late Ashgill of the Baltic region, Gotland and Estonia, may be applied to the Gamachian of Anticosti and the late Ordovician of Portugal. The possibilities for correlation offered by the Llandovery acritarchs of Anticosti concern affinities with, principally and in decreasing order, the Gaspé area of Canada, England and Wales, Belgium and the U.S.A. In particular, the first occurrences of *Domasia* and of *Dilatisphaera williereae*, the levels of which are still inadequately known on Anticosti, should permit correlation with at least the Aeronian and the Telychian of the Anglo-Welsh area. Palynological data for the Rhuddanian of the latter area allow only a local zonation at present.

Conclusions

Owing to the dearth of published data, acritarchs have not been used directly as one of the criteria for the choice of an Ordovician–Silurian boundary during the activities of the I.U.G.S. working group from 1974 to 1985. The Anticosti deposits are those likely to provide the most reliable palynological correlations, not only in the immediate vicinity of the systemic boundary but also at least from the early to middle Ashgill to the late Llandovery (Telychian, C_5). This view is supported by the indication both of relatively continuous data and of direct correlations with the Gaspé area from the base of the Rhuddanian upwards, and the Anglo-Welsh area from the Aeronian upwards.

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Appendix

Locality data for Anticosti Island, Province of Québec, Canada. All locality numbers in Lespérance (1981: 1).

Loc. A-2A: Pointe Laframboise area. Sample A-2A1: Ellis Bay Formation, Member 7, 0·40 m above oncolithic bed. Sample A-2A2: Becscie Formation, 0·60 m above base.

Loc. A-2B: west side of Ellis Bay, section proposed as Ordovician–Silurian boundary stratotype by Barnes & McCracken (1981). Samples A-2B2 to A-2B6: Ellis Bay Formation; A-2B2: member 4, 3 m below top of member; A-2B3: member 5, 5 m below top of member; A-2B4: member 6, 0·30 m below top of member; A-2B5 and A-2B6: member 7, respectively just above and 0·75 m above oncolithic bed. Samples A-2B7 to A-2B9: Becscie Formation. A-2B7: immediately above the biohermal level of member 7 of the Ellis Bay Formation. A-2B8 and A-2B9: respectively 1·30 m and 25 m (approximately) above A-2B7.

Loc. A-6A and sample A-6A: Cap Jupiter, north of mouth of Rivière Jupiter, Jupiter Formation, about 3 m above base of member 3.

Loc. A-7A: 4 km southeast of Pointe du Sud-Ouest. Sample A-7A1: Jupiter Formation, 4 m below its top.

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